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पोत निर्माण — समुद्री डीज़ल इंजनों का परीक्षण — रीति संहिता

(पहला पुनरीक्षण)

Indian Standard

SHIPBUILDING — TESTING OF MARINE DIESEL ENGINES — CODE OF PRACTICE

(First Revision)

ICS 47.020.20

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Price Group 4

Marine Engineering Sectional Committee, TED 19

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Marine Engineering Sectional Committee had been approved by the Transport Engineering Division Council.

This standard was first published in 1967. Revision of this standard has been taken up to align it with ISO 3046 Reciprocating internal combustion engines — Performance, Part 1-1986 Standard reference conditions and declaration of power-fuel consumption and lubricating oil consumption and Part 2-1987 Test methods.

The aim of preparing this Indian Standard code of practice for testing of marine diesel engines is to establish unified regulations for the preparation, execution and interpretation of tests at the manufacturer's works and on board. These tests are intended for certifying the conformity with the contract specifications and verifying the guarantees given by the supplier.

Notwithstanding what is stated in this standard, the practice for testing of marine diesel engines shall comply, in addition, to the latest rules and requirements of the Classification Societies and Statutory Authorities in all respects.

The information to be supplied by the purchaser to the supplier is given in Annex A. The information to be supplied by the supplier to the purchaser is given in Annex B.

Indian Standard

SHIPBUILDING — TESTING OF MARINE DIESEL ENGINES — CODE OF PRACTICE

(First Revision)

1 SCOPE

This code applies to testing of marine diesel engines for main propulsion and auxiliary drives. It excludes main propulsion diesel engines for fishing vessels up to 15 m length/25 NRT, for which a separate Indian Standard IS exists.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
8013 : 1985	Performance requirements and testing of marine diesel engines for fishing vessels (*first revision*)
10000	Methods of tests for internal combustion engines
(Part 3) : 1980	Measurements for testing units and limits of accuracy
(Part 4) : 1980	Declaration of power, efficiency, fuel consumption and lubricating oil consumption
(Part 7) : 1980	Governing tests for constant speed engines and selection of engines for use with electrical generators
13018 : 1990	Internal combustion engines — Method of test for pressure charged engines

3 TERMINOLOGY

For the purpose of this standard, following definitions shall apply.

3.1 General

3.1.1 *Supplier*

The party supplying the material. Supplier may or may not be the manufacturer of material. The term 'Supplier' shall also cover any party with whom the supplier places an order for partial compliance.

3.1.2 *Purchaser*

The party purchasing the material. The term 'purchaser' shall also cover person or persons authorised in writing by purchaser to act on his behalf for inspection of material.

3.2 Classification of Engines According to Use

3.2.1 *Main Engine*

Engine intended for main propulsion.

3.2.2 *Auxiliary Engine*

An engine intended for purpose other than the propulsion of ships.

3.3 Standard Reference Conditions

For the purpose of determining the power and fuel consumption of engines following standard reference conditions shall be used:

Total barometric pressure p_r = 100 kPa

Air temperature T_r = 298 K (25°C)

Relative humidity ϕ_r = 30 percent

Charge air coolant temperature T_{cr} = 298 K (25°C) or as stated by the manufacturer

NOTE — Relative humidity of 30 percent at a temperature of 298 K corresponds to a water vapour pressure of 1 kPa. Hence corresponding dry barometric pressure is 99 kPa.

4 AUXILIARIES

4.1 Introduction

In order to show clearly the conditions under which power is determined, it is necessary to distinguish those auxiliaries which affect the final shaft output of engine and also those which are necessary for continuous or repeated use of the engine.

Items of equipment fitted to the engine and without which the engine could not in any circumstances operate at its declared power are considered to be engine components and are not, therefore, classed as auxiliaries (such items as fuel injection pump, exhaust turbocharger and charged air cooler are in this category of engine components).

4.2 Dependent Auxiliary

Item of equipment driven by the engine and which affects the final shaft output of the engine.

4.3 Independent Auxiliary

Item of equipment which uses power supplied from a source other than the engine.

4.4 Essential Auxiliary

Item of equipment which is essential for the continued or respected operation of the engine.

4.5 Non-essential Auxiliary

Item of equipment which is not essential for the continued or repeated operation of the engine.

5 POWER AND SPEED

5.1 Power

The power output of the engine should be specified in 'kW', with statement of corresponding engine speed. Equivalent values in 'HP' may be additionally mentioned.

Unless otherwise stated the power referred in this standard is the 'brake power'.

Any statement of brake power shall be supported by the following list of auxiliaries:

a) Essential dependent auxiliaries as defined in **4.2** and **4.4**,
b) Essential independent auxiliaries as defined in **4.3** and **4.4**, and
c) Non-essential dependent auxiliaries as defined in **4.2** and **4.5**.

The details of above categories of auxiliaries are given in Annex C.

5.2 Net Brake Power

Net brake power is the brake power measured when the engine is using only the auxiliaries listed in **5.1**(a).

5.3 Speed

The speed of an engine is the mean rotational speed of its crankshaft or crankshafts in revolution per minute.

5.4 Kinds of Power Output

5.4.1 *Continuous Power*

Continuous power is the net brake power which the engine is capable of delivering continuously, between the normal maintenance intervals stated by the supplier, at the stated speed and under stated ambient conditions prescribed by the supplier being carried out.

5.4.2 *Overload Power*

Overload power is the net brake power which an engine may be permitted to deliver at stated ambient conditions (as mentioned in **3.3**), immediately after working at the continuous power.

The duration and frequency of use of overload power, which is permitted, will depend on service application, but adequate allowance shall be made in setting the engine fuel stop or permit the overload power to be delivered satisfactorily. The overload power shall be expressed as a percentage of continuous power, together with the duration and frequency permitted and the appropriate engine speed.

Unless otherwise stated an overload power of 110 percent of the continuous power at a speed corresponding to engine application is permitted for a period of one hour, without interruptions, within a period of 12 hours of operations.

NOTES

1 The power of marine main propulsion engine is normally limited to the continuous power so that the overload power can not be given in service. However, for special applications, marine main propulsion engines may develop overload power in service.

2 If the engine application is not determined the engine supplier shall specify the overload power and corresponding engine speed.

5.4.3 *Fuel Stop Power*

Fuel stop power is the power which an engine is capable of delivering during a stated period corresponding to its application, and at stated speed and under stated ambient conditions, with the fuel limited so that the fuel stop power can not be exceeded.

5.4.4 *Sprint Rating*

An engine is rated for a very short duration and rated at slightly higher speed than intermittent speed for specified application.

5.5 Kinds of Statements of Power

5.5.1 *IS Standard Power*

This is the continuous net brake power which the engine manufacturer declares that an engine is capable of delivering continuously, between the normal maintenance intervals stated by the manufacturer, and under the following conditions:

a) At a stated speed under the operating conditions of the engine manufacturer's test bed.

b) With the declared power adjusted to the standard reference conditions given in **3.3**, and tested in accordance with IS 10000 (Part 4).

c) With the maintenance described by the engine manufacturer being carried out.

5.5.2 *Service Power*

Service power is the power determined under the ambient and operating condition of an engine application.

To establish service power, following conditions shall be taken into account :

a) The ambient conditions, or any nominal ambient conditions according to the special requirements of inspecting and/or legislative authorities and/or classification societies, as specified by the purchaser (*see* Annex A).

NOTE — For example, the following nominal ambient conditions apply to main and auxiliary RIC engines on ships for International Association of Classification Societies (IACS) unrestricted service:

Total barometric pressure P_x = 100 kPa
Air temperature T_x = 318 K (45°C)
Relative humidity ϕ_x = 60 percent
Sea water temperature (charge air coolant inlet) T_{cx} = 305 K (32°C)

b) The nominal duty of the engine;

c) The expected interval between the maintenance periods;

d) The nature and amount of supervision required; and

e) All information relevant to the operation of the engine in service (*see* Annexes A and B).

6 DECLARATIONS OF FUEL CONSUMPTION

6.1 Fuel Consumption

Fuel consumption is the quantity of fuel consumed by an engine per unit of time at a stated power and under stated ambient conditions.

Fuel consumption shall be expressed in kg/h for liquid fuels.

6.2 Specific Fuel Consumption

Specific fuel consumption is the fuel consumption per unit of power, per unit of time and shall be declared in g/kWh.

6.3 IS Specific Fuel Consumption

This is the specific fuel consumption at the IS standard power (*see* **5.5.1**). If not otherwise specified by the manufacturer, a declared specific fuel consumption shall be considered to be the IS Specific fuel consumption.

NOTE — The specific fuel consumption to be declared by the manufacturer, with lower calorific value of fuel. The lower calorific value is to be taken as 42 000 kJ/kg (10 030 kcal/kg), if not declared by the manufacturer.

Unless otherwise stated, a deviation of +5 percent is permitted for specific fuel consumption at the declared power.

7 DECLARATION OF LUBRICATING OIL CONSUMPTION

7.1 This is the quantity of lubricating oil consumed by an engine per unit of time. This quantity is used for guidance. It shall be expressed in litres or kilograms per engine operating hour at the declared power and engine speed.

7.2 The lubricating oil consumption after a stated period of running-in shall be declared.

7.3 The oil discarded during an engine oil change shall not be included in the lubricating oil consumption declaration.

7.4 The grade of lubricating oil shall be declared.

8 TESTS

8.1 Kind of Tests

8.1.1 *Acceptance Test*

Test carried out as an overall check on the manufacturing quality, and to establish that the contractual commitments have been fulfilled.

8.1.2 *Type Test*

Test carried out on representative engines of a certain engine type to establish the main performance data of the engine, and as far as possible, to enable their reliability and durability in service to be assessed.

8.1.3 *Special Tests*

Tests additional to acceptance or type tests carried out to meet the requirements of inspecting and legislative authorities, classification societies or purchaser.

NOTE — Special tests are subject to agreement between the supplier and the purchaser.

9 EXTENT OF TESTS

The programme of acceptance and type tests shall be established by the manufacturer.

It is the responsibility of the manufacturer to define the extent of measurements, which shall be agreed with the purchaser. Table 1 may be taken as guide for selecting the engine groups appropriate to the test measurements given in the List A (*see* **11**).

For mass produced engines not all tested on load, an adequate inspection procedure may be used instead of full acceptance tests.

Dependent on the test categories and the extent of tests, four lists of recommended test measurements, calculated values and functional checks (List A, B, C and D) are given in **12**.

Table 1 Measurement Selection Guide

(*Clauses* 9 *and* 12.1.5)

Engine Group No.	Typical Characteristics of Engine Group
1	Engines the operating conditions of which are not measured in service, usually with maximum design speeds of more than 1 800 rev/min
2	Naturally aspirated engines with maximum design speeds of approx 1 500 rev/min and above
3	Pressure charged engines with maximum design speeds of approx 1 500 rev/min and above
4	Engines with maximum design speeds of approx 250 to 1 500 rev/min
5	Engines with maximum design speeds up to 250 rev/min

10 TEST CONDITIONS

10.1 Before an engine test, the supplier shall submit complete technical documentation concerning the engine type and application, when mutually agreed by the supplier and the purchaser.

10.2 A period of running-in and preliminary test considered adequate by the manufacturer shall precede the acceptance test.

10.3 The measurements of an acceptance or type test shall be carried out only when engine has reached stable conditions as specified by manufacturer.

10.4 Unless otherwise agreed between the supplier and the purchaser, test shall be carried out on the test bed at manufacturer's works.

10.5 Test shall be carried out on the engine equipped with dependent auxiliaries, necessary for its operation either or belonging to the engine test bed equipment supplied with the engine.

10.6 Provided that the contractual requirements are fulfilled, test bed equipment may be used.

10.7 Only those engines which are supplied with built in transmission systems (for example, hydraulic mechanism, reversing coupling) or electric generators and which can not be tested separately, need to be tested with the transmission system or generator coupled to the engine.

If engines are tested with coupled driven machinery or a transmission system which is separable, then any variation in power, due to these coupled items, shall be eliminated from the declared power.

10.8 If the acceptance test is carried out on site and the rated power at the corresponding speed can not be verified or achieved, due to the special circumstances of the installation, and/or situation of installation the manufacturer and the purchaser shall accept the test report of the test at the manufacturer's work test bed as valid, and verify only:

- — the declared speed at a power other than the rated power, or
- — the rated power at a speed other than the rated speed.

In either case the measurement of the fuel consumption shall be omitted.

10.9 During tests on engine, no additional measures other than those required to maintain the test conditions and those required for normal operation as given in the working manual, may be used.

10.10 The only interruptions in testing permitted are those necessary for engine maintenance as given in the working manual. In all other cases, if an interruption should occur caused by some defect in parts of engine, the decision on whether to repeat the test partially or entirely shall be mutually taken by the manufacturer and the purchaser.

10.11 Correction or Adjustment of Power Output and Specific Fuel Consumption

10.11.1 When the test condition differ significantly (*see* **3.3**) from standard reference conditions, or from site conditions, the test power output may be, if required, corrected by calculations. Alternatively, the engine may be tested at a substitute power and/or under test conditions altered artificially to simulate the site conditions.

The power correction factors can be determined as per IS 10000 (Part 4) for Naturally Aspirated engines, and as per IS 13018 for Turbocharged engines.

10.11.2 This correction will be carried out to determine whether the values of power and specific fuel consumption are attained under engine test conditions corresponding to specified values.

10.11.3 The specific fuel consumption shall be determined using the details given in IS 10000 (Part 4) for Naturally Aspirated engines, and in IS 13018 for Pressure charged engines.

10.11.4 Engines tests may be carried out at any other (non-declared) power under ambient conditions created artificially to simulate site condition.

11 MEASUREMENT TECHNIQUES

Refer IS 10000 (Part 3) for Naturally Aspirated engines and IS 13018 for Pressure charged engines.

12 TEST PROCEDURE

12.1 Acceptance Test

12.1.1 Acceptance tests comprise of a specified sequence of power setting with measurements calculated values given in List A and B functional checks given in List C.

12.1.2 The duration of total acceptance test depends on the engine power and application, and shall be agreed to between the supplier and the purchaser, before commencements of tests.

12.1.3 The measurements in the List A normally shall be made according to the specified engine group for each operating condition wherever appropriate and where provision exists on the engine for doing so. Where measurements are carried out for the purpose of verifying the declaration of power, engine speed and fuel consumption, valid measurements shall be carried out at least twice. A measurement shall be considered valid if the variations of the engine brake torque and engine speed values in relation to settings of the operating values, do not exceed ± 2 percent. The variation of the power output during this period shall not exceed ± 3 percent.

Measurements in List A are arranged in an ascending order of test measurement complexity and are presented for guidance when the contract is drawn up between the supplier and the purchaser. Either party may, by agreement, add to or delete from measurement in List A, to suit the particular type of engine involved. Where no provision exists on engine for a particular measurement, this shall be stated by the manufacturer.

List A Test Measurements

No.	Parameter to be Measured	Engine Group No. 1	2	3	4	5
A1	Barometric pressure, humidity and ambient temperature	×	×	×	×	×
A2	Engine speed or cycle frequency	×	×	×	×	×
A3	Engine brake torque and/or power	×	×	×	×	×
A4	Fuel pump or governor or throttle control rod setting	×	×	×	×	×
A5	Fuel consumption		×	×	×	×
A6	Lubricating oil pressure		×	×	×	×
A7	Temperature and pressure of exhaust gas leaving the engine		×	×	×	×
A8	Air intake pressure and temperature at the engine or pressure charger inlet		×	×	×	×
A9	Exhaust gas temperature at the turbine inlet			×	×	×
A10	Boost pressure in the air manifold			×	×	×
A11	Turbocharger speed				×	×
A12	Coolant mean temperature in and out of cylinder block			×	×	×
A13	Lubricating oil temperature at the engine inlet and outlet			×	×	×
A14	Boost pressure drop through the charge air cooler				×	×
A15	Boost pressure after each charge air cooler				×	×
A16	Charge air temperature after each charge air cooler				×	×
A17	Coolant mean temperature at the charge air cooler inlet and outlet				×	×
A18	Maximum cylinder pressure				×	×
A19	Exhaust gas pressure at the turbine inlet				×	×
A20	Exhaust gas temperature of each cylinder (*see* Note 2)				×	×
A21	Individual coolant circuit temperature and pressures				×	×
A22	Lubricating oil pressure in individual circuits, for example turbocharger, piston cooling, etc				×	×
A23	Lubricating oil pressure before and after filters and coolers				×	×
A24	Secondary coolant and lubricating oil temperatures in and out of heat exchanger				×	×
A25	Fuel supply pressure and temperature				×	×
A26	Compression pressure					×

NOTES

1 Additional items may be included by agreement between supplier and purchaser.

2 For engines fitted with monoblock fuel injection equipment, this may be deleted.

12.1.4 Where appropriate, the supplier shall supply the calculated values given in List B on the basis of test measurements obtained from List A.

List B

B1 — Brake power

B2 — Brake specific fuel consumption

12.1.4.1 The measurement of fuel consumption shall be carried out during measurement of power.

12.1.4.2 Fuel fed to the engine which is surplus and not consumed shall be taken into account in the measurements accordingly.

12.1.5 *Functional Checks*

List C comprises functional checks which may additionally be carried out on engine in groups 2 to 5 in Table 1. The selection from List C shall be made by agreement between the supplier and the purchaser.

List C

Checks shall be carried out to demonstrate the following :

C1 — The correct functioning of over speed limiting device.

C2 — The correct functioning of govering system.

C3 — The ability of all malfunction protection and warning devices to respond correctly to the fault conditions in which they should operate (for example, low lubricant oil pressure, high lubricating oil temperature, high coolant temperature, pressure rise in crankcase, etc).

C4 — The correct functioning of all automatic pressure and temperature control.

C5 — The ability of starting system to perform, in accordance with the contract.

Following checks, wherever applicable may also be carried out if agreed to between the supplier and the purchaser in advance.

C6 — The correct functioning of the reversing mechanism, built in the reverse reduction gear and couplings.

C7 — That the temperature of the important components is satisfactory.

C8 — Crankweb deflection.

C9 — Stability of the engine on its support.

C10 — The condition after test of one or more piston and cylinder assemblies and bearings chosen by the inspection.

NOTE — Additional checks may be included by agreement between the supplier and the purchaser.

12.2 Type Tests

12.2.1 A type test comprises a specified sequence of power/engine speed combined values, reversals and stops.

12.2.2 Type tests will include, as far as applicable, all measurements, calculations and functional checks in List A, List B and List C.

Parameter in List D, may be checked additionally, if agreed to between the supplier and the purchaser.

List D

D1 — Air consumption

D2 — Lubricating oil consumption

D3 — Dismantling, inspection and measuring of important parts subject to wear.

12.3 Special Tests

Any special tests which may be required by inspecting authorities, classification societies, by legislation or by the purchaser and shall be subject to agreement between supplier and such authorities, and/or the purchaser.

13 SPEED GOVERNING

Refer IS 10000 (Part 7).

14 TEST REPORT

14.1 The manufacturer shall provide a test report.

14.1.1 Normally, acceptance test reports shall be provided for engine group number 3, 4 and 5 only.

14.1.2 Type test reports shall be provided for all groups of engines.

14.2 The test report shall include engine identification and the following test information:

a) Date, place, nature of test and inspecting authority,
b) Type of fuel and lubricating oils used during tests,
c) Dependent auxiliaries, engine settings and proprietary equipment,
d) Table of values measured during the test,
e) Interpretation of certain measurements as required, and
f) Reference to this standard.

ANNEX A

(*Foreword* and *Clause* 5.5.2)

INFORMATION TO BE SUPPLIED BY THE SUPPLIER

The supplier shall supply the following information :

a) The declared powers, and where appropriate, their tolerances.

b) The corresponding crankshaft and output shaft speed.

NOTE — For applications of variable speed engines, it is common practice to supply a power/speed diagram covering the ranges of power over which the engine can be used in continuous and in short period operation.

c) The direction of rotation of output shaft.

d) The number and arrangement of cylinders.

e) Whether the engine is two stroke or four stroke, naturally aspirated, mechanically pressure charged or turbocharged and whether with or without charge air cooler.

f) The quantity of air required for the operation of the engine for :
  - — combustion and scavenging
  - — cooling and ventilation

g) The method of starting, apparatus supplied and additional apparatus required.

h) The type and grade of lubricating oil(s) recommended.

j) The type of governing :
  - — If variable speed duties, the working speed range and idling speed.
  - — If necessary the critical speed range shall be indicated.

k) The method of cooling and the capacity of the cooling system with rates of circulation of cooling fluids.

m) Whether hot air discharge ducting to be fitted (for air cooled engine only).

n) A schedule of recommended maintenance and overhaul periods.

p) Specifications and lower calorific values of fuels recommended.

q) Maximum permissible back pressure in exhaust system and maximum permissible intake depression.

r) Torsional vibration calculations (as applicable) based on the data furnished by the purchaser.

s) Any other information appropriate to the particular engine application.

ANNEX B

(*Foreword* and *Clause* 5.5.2)

INFORMATION TO BE SUPPLIED BY THE PURCHASER

The purchaser shall supply the following information concerning the required power:

a) The application and power required from the engine and details arising therefrom.

b) The expected frequency and duration of the required powers and corresponding engine speed.

c) Site conditions : if different from those specified in **5.5.2**.

d) Whether the engine is to comply with any classification society or national or international requirements.

e) The probably period for which the engine will be running continuously, and the duration of maximum and minimum load.

f) Any other information appropriate to the particular engine application.

ANNEX C

(*Clause* 5.1)

EXAMPLES OF AUXILIARIES WHICH MAY BE FITTED

(These lists are given for guidance purpose only and are not necessarily complete)

List A — Essential dependent auxiliaries (*see* **4.2** and **4.4**):

1) Engine driven lurbicating oil pressure pump.

2) Engine driven lubricating oil scavenge pump for dry sump engines.

3) Engine driven engine cooling water pump.

4) Engine driven raw water pump.
5) Engine driven radiator cooling fan.
6) Engine driven engine cooling fan for air cooled engines.
7) Engine driven fuel feed pump.
8) Engine driven fuel pressure pump for common rail or servo injection system.
9) Engine driven scavenge air blower and/or charge air blower.
10) Engine driven generator, air compressor or hydraulic pump when supplying power to items in List B.
11) Engine driven cylinder lubricating pump.
12) Air cleaner or air silencer (normal or special).
13) Exhaust silencer (normal or special).

List B — Essential independent auxiliaries (*see* **4.3** and **4.4**):

1) Separately driven lubricating oil pressure pump.
2) Separately driven lubricating oil scavenge pump for dry sump engines.
3) Separately driven engine cooling water pump.
4) Separately driven raw water pump.
5) Separately driven radiator cooling fan.
6) Separately driven engine cooling fan for air cooled engines.
7) Separately driven fuel feed pump.
8) Separately driven fuel pressure pump for common rail or servo injection system.
9) Separately driven scavenge air blower and/or charge air blower.
10) Separately driven crankcase extractor fan.
11) Separately driven cylinder lubricating pump.
12) Governing or control system using power from an external source.

List C — Non-essential dependent auxiliaries (*see* **4.2** and **4.5**):

1) Engine driven starting air compressor.
2) Engine driven generator, air compressor or hydraulic pump when supplying power to items not in List B.
3) Engine driven bilge pump.
4) Engine driven fire pump.
5) Engine driven ventilation fan.
6) Engine driven fuel transfer pump.

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